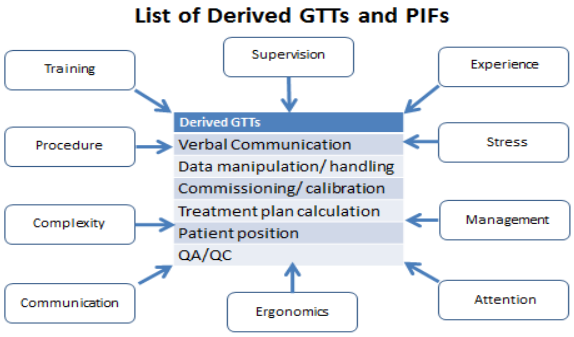

Figure 1: GTTs and PIFs

GTT Description	Mapped Tasks
Input or transfer of data in paper or electronic format	• Look and copy/input data • Input data from memory • Input data while performing some physical task • Input data while someone is dictating • Import data • Export data

Table 1: GTT- Data Manipulation/ handling

PIF	Anchor Questions
Training	• Is there a systematic training program for newcomers? • Is the task part of training? • Is there training for new equipment or technique? o Facility training? o Vendor training? • Updated in accordance with the practice? • Training on proper use of tools?

Table 2: PIF- Training, anchor questions

Conclusions: Incident analysis, task analyses, cognitive models and existing HRA databases have been used to build the qualitative taxonomic structure for the HRA method. These taxonomies are a first step to support the systematic analysis of potential errors and influencing factors.
Next steps:
Complete characterization of GTTs and PIFs using domain expert opinions and the adapted cognitive models. Develop the model for estimating error probabilities and test the HRA method to assess patient safety at a specific RT center.

PO-0995

Evaluation of VMAT-RapidArc, IMRT-VERO and proton-RT for a hypofractionated scheme of prostate cancer treatment

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Purpose/Objective: Dosimetric evaluation of comparative plans for a hypofractionated scheme of very low to intermediate risk cancer treatment (Grant AIRC - IG 13218), in order to define the treatment technique that obtains the best coverage of the target volume minimizing the dose to surrounding organs at risk (OARs).
Materials and Methods: The CT and multiparametric MR scans of ten patients previously treated for prostate adenocarcinoma were used to identify the dominant intraprostatic lesion (DIL). Comparative treatment plans were obtained with three different techniques, namely Volumetric Modulated Arc Therapy (VMAT) obtained with Varian Eclipse for Trilogy, Intensity Modulated Radiation Therapy (IMRT) with BrainLab iPlan for VERO and proton-therapy (PT) with Syngo-TPS. The dosimetric scheme consists of five fractions with 7.25 Gy/fr for the prostate and a concomitant boost of 7.5 or 9 Gy/fr for the DIL. The different prescription doses were tested on subgroups of five patients each, conveniently selected in order to obtain homogeneous groups in terms of DILs volume and position. The target coverage was considered a priority respect to the OARs constraints. DVH of target volumes and OARs and homogeneity (HI), conformity (CI) and gradient score (GSI) indexes were calculated and compared. Wilcoxon signed rank test was used to evaluate statistically significant differences among techniques.
Results: Median values of target coverage and statistical analysis is shown in Table, with statistical significant differences highlighted. The less respected constraints are those related to posterior rectal wall and posterior anal canal wall, for which a maximum dose inferior to 16 Gy is required. In particular, for posterior anal canal wall the dose limit is exceeded in 9 out of 10 VMAT plans, 5/10 IMRT plans and 3/10 PT plans. For posterior rectal wall, the dose limit is exceeded in 10/10 VMAT plans, 7/10 both IMRT and PT plans. The constraints for urethra (D_{max}<40 Gy and V_{36Gy}<50%) is also critical: the maximum dose is exceeded in 3/10 plans in each technique and the volumetric constraint is exceeded in 4/10 VMAT plans, 10/10 IMRT plans and 8/10 PT plans. Overall, the 90.3% and 86.9% of dosimetric constraints are fulfilled in plans with 7.5 and 9 Gy of boost doses, respectively. The analysed indexes are comparable among methods, with a slight superiority in homogeneity for VMAT plans and in gradient score for PT plans.

Boost dose	Index		Median values			p-values (Wilcoxon signed rank test)		
			VMAT	IMRT	PT	VMAT vs. IMRT	VMAT vs. PT	IMRT vs. PT
7.5 Gy	Prostate	$D_{95\%}$(%)	96.9	96.7	96.8	0.841	0.690	0.341
		$D_{98\%}$(%)	96.5	94.3	94.9	**0.008**	0.548	0.548
		HI	0.07	0.10	0.12	0.095	**0.008**	0.222
		CI	2.16	2.16	2.05	1.000	0.310	0.095
	DIL	$D_{95\%}$(%)	96.7	98.1	98.9	0.056	**0.008**	0.841
		$D_{98\%}$(%)	96.4	97.7	98.4	0.222	**0.016**	0.841
		HI	0.05	0.04	0.06	0.151	0.310	0.056
		CI	43.33	63.65	65.59	0.690	0.690	1.000
		GSI	-43.9	-64.8	35.8	0.310	**0.008**	**0.008**
9 Gy	Prostate	$D_{95\%}$(%)	97.3	99.9	97.6	0.151	0.897	0.151
		$D_{98\%}$(%)	96.3	98.5	95.5	0.421	**0.016**	0.151
		HI	0.22	0.18	0.20	0.222	0.548	0.095
		CI	2.37	2.34	2.17	0.841	0.690	0.690
	DIL	$D_{95\%}$(%)	97.7	95.0	95.7	0.079	**0.008**	0.548
		$D_{98\%}$(%)	97.0	93.8	93.7	0.095	**0.008**	1.000
		HI	0.08	0.13	0.15	0.151	**0.008**	0.310
		CI	4.71	4.03	8.43	0.548	0.841	0.548
		GSI	-130.7	-152.1	-88.2	0.690	0.222	0.095

Conclusions: Preliminary results show an overall equivalence among different techniques in planning of hypofractionated prostatic treatments with concomitant boost. Further analysis will include time of treatments and NTCP calculation. In order to enrich the statistical analysis, plans with both boost doses will be realized on the complete patients cohort. Moreover, plans realized with CyberKnife will be also included in the analysis.

PO-0996

A novel probabilistic risk assessment technique for radiotherapy

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Purpose/Objective: Advances in radiotherapy (RT) offer better treatment options for patients. The evolving technology increases the complexity of the treatment process. The quality control mechanisms used in radiotherapy need to evolve appropriately. Widely publicised incidents such as those seen in New York, Glasgow and Epinal highlight the need to adapt to a more systematic approach to risk assessment in RT. The aviation, nuclear and chemical industries have been developing safety tools for decades. Failure Mode and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) used in these industries have been suggested for RT. The novel methodology presented here integrates human error probability modelling with components of FMEA and FTA and applies them in a clinical setting.

Materials and Methods: This proposed risk assessment method is a hybrid of current techniques. Graphical representation of the RT system demonstrates the relationship between tasks, equipment, software and users involved in the treatment process. Figure 1 shows part of the treatment delivery process and the relevant tasks. A modified version of the process described by Ford et al (Med Phys. 2012 Dec;39(12):7272-90) was used to evaluate the RT pathway. The components of each process were critically analysed to ascertain their fault potential. The baseline values from the Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H) methodology (2005, NRC Report) were used to estimate human error probability. This model was applied to the RT pathway (from patient CT simulation to final treatment) for patients with prostate cancer.

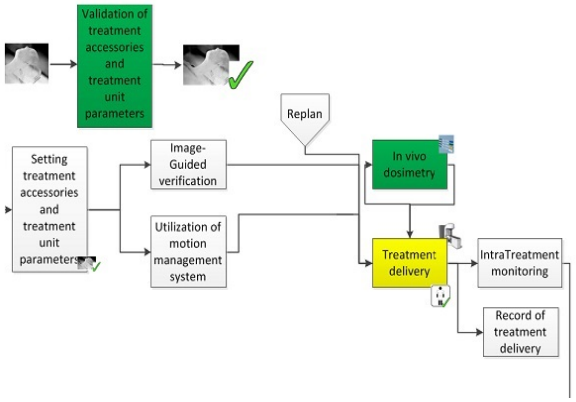

Fig. 1 Treatment delivery process and tasks involved

Results: Twenty one error modes and eighteen safety barriers that could affect the patients' treatment were identified. The remaining tasks were classified as (a) irrelevant to patient safety or (b) errors acting as a process inhibitor. In ideal human performance conditions this model estimated an incident rate of 0.17% (excluding commissioning of treatment units). These incidents refer to any unplanned deviation to standard treatment. The incident rate increases dramatically when performance shaping factors such as stress, available time, complexity etc are introduced into the system.

Conclusions: This novel method of risk analysis is highly beneficial in evaluating the effectiveness of the safety system in place in RT. This model can be used to assess the propagation of errors and highlights the areas in the RT process that can be improved. The human error probability is an estimated value which can fluctuate under different conditions. The use of quantitative human errors values allows the utilisation of FTA mathematics. This risk assessment technique can be used to review new processes and their application within the system without compromising patient safety. This is a fluid model that can be constantly updated.

PO-0997

Validation of a multi-layered automatic detection system to improve quality and safety in radiotherapy

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Purpose/Objective: To evaluate a newly-developed automatic system for detecting errors in the planning and delivery of radiotherapy.